Stimulation of Optical Phonons in Deuterated Palladium

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Progress made since 2007 in the triggering of excess power by terahertz stimulation of deuterated palladium is reported. The stimulation was provided by tuning dual lasers to one of three specific beat frequencies corresponding to the known optical phonon frequencies of deuterated palladium (8, 15, 20 THz). Results so far imply that optical phonons may be involved in the Fleischmann-Pons effect, giving preliminary support to Hagelstein's phonon theory.

1. Introduction

As is well known by now, Fleischmann, Pons and Hawkins first proposed the idea that nuclear reactions might be induced in deuterated palladium on March 23, 1989 [1]. The idea was controversial from its inception and was based on experimental results, not established nuclear theory. Due to the absence of energetic particles commensurate with the energy produced, whatever process is responsible must involve new physics.

In 1993 Miles and his collaborators reported the presence of ^{4}He in roughly the amount expected from the mass energy different from two deuterons, suggesting that it was produced in amounts commensurate with the excess energy observed [2]. There is now enough diverse experimental evidence to suggest that a new nuclear process is occurring in the solid state at room temperature.

1.1. Hagelstein's Phonon Theory

From the beginning, one of the authors (Hagelstein) pondered the role of phonons in the solid state fusion of deuterium. His early work proposed a coherent fusion mechanism in which nuclear energy is coupled into phonon modes (reference [3], presented at the ASME meeting December, 1989). In his conjecture 4, page 847 of reference [4], one finds: "Anomalies in metal deuterides are stimulated by strong phonon excitation." Hagelstein suggests that the optical phonon modes are the most likely candidates, especially the modes with low group velocity typically located at the edge of an optical phonon mode [5]. In palladium deuteride, the band edges occur near 8 and 15-16 THz [6,7].

2. Experiment Meets Theory

The work discussed in this paper began in March 2007 as a series of experiments conducted by Letts and Cravens in collaboration with Hagelstein. Our goal was to see if an experimental connection could be made with the phonon aspects of Hagelstein's theory. Before experiments were run, Hagelstein predicted that the edges of the optical phonon band would be the best candidates for stimulation to produce excess power. This region is where low group-velocity compressional phonon modes exist. This is consistent with our observations near 8 and 15 THz but the response near 20 THz requires an alternate explanation. Perhaps the simplest conjecture for this higher frequency response is due to proton contamination, which might be expected to produce a zero-group velocity band edge near 20 THz.

2.1. Instrumentation and Calorimetry

This work covers 19 tests from 3 cells; two time periods are involved – March 2007 to May 2007 and then April 2008 to the present. The goal of this work is the creation of a beat frequency versus excess power graph to determine if stimulation of the three optical phonon modes of palladium deuteride leads to the observation of excess power.

All experiments were conducted in Austin, Texas. Isoperibolic calorimetry was used on all tests. The standard deviation of power output from the calorimeter was approximately 20 mW and was very stable over a typical 10 hour experimental run (Figure 1).

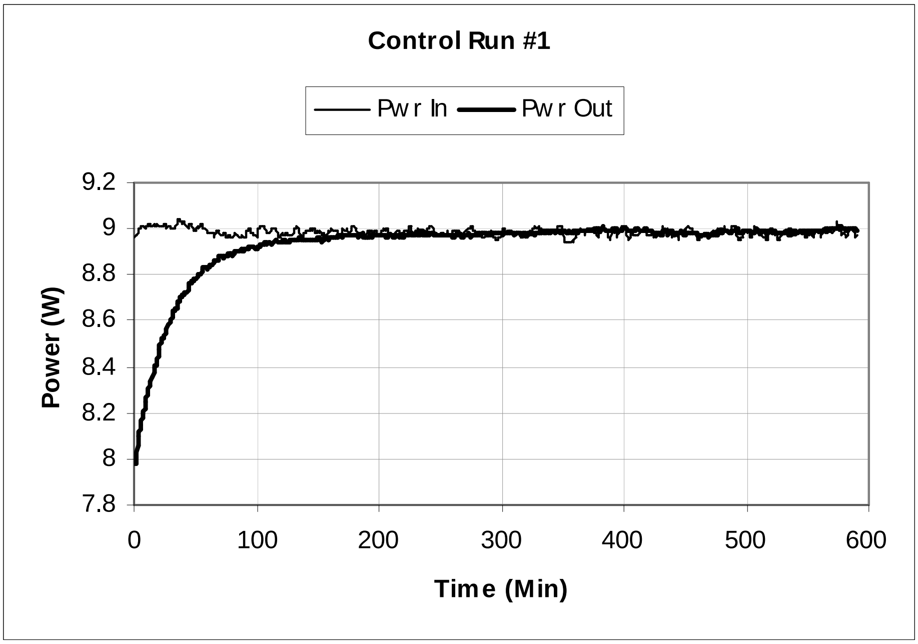
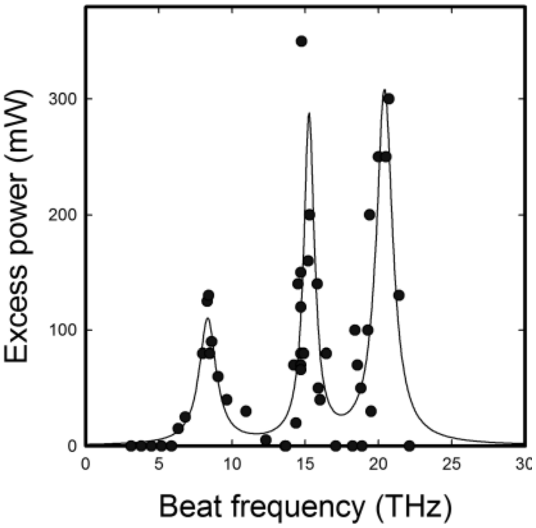


Figure 1. The isoperibolic calorimeter demonstrates good long-term stability when the cell is not producing excess power.

2.2 Experimental

Our cells were closed and consisted of a rectangular billet of palladium as the cathode and a coiled platinum wire as anode. The electrolyte was typically 100 mL of LIOD at 0.5 M concentration. This work consists of 49 data points from 19 runs and 3 electrolysis cells. The data points are listed table 1 (see the Appendix). We plotted the data in table 1 and a clear pattern emerged showing three frequencies capable of triggering excess power from deuterated palladium.



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Frequency (THz)	Width (THz)
8.3	0.70
15.3	0.44
20.4	0.68

Figure 2. Three specific triggering beat frequencies. Vertical scale is XP in mW. Also shown is a curve from a least squares fit to a sum of three Lorentzians $\Sigma\, c_j/[(\omega-\omega_j)^2+\gamma^2]$, where the center frequencies ($\omega_j/2\pi$) and broadening (width=$\gamma_j/2\pi$) parameters are indicated.

3. Discussion

Can these experiments connect with any known physics? On the face of it, the observation of a thermal response at the specific beat frequencies 8, 15 and 20 THz [Figure 2] combined with the observed dependence on polarization implicates compressional optical phonon modes in PdD as participating in the physical process responsible for excess heat production in the Fleischmann-Pons excess heat effect. The lower two specific beat frequencies observed (8 and 15 THz) are consistent with the interpretation of optical phonon modes with low group velocity in PdD. The higher frequency response (20 THz) represents a conundrum for a PdD explanation, since it lies above the LO band edge. One possible resolution of this is to assume that H is present as a significant impurity, and that 20 THz is due to an LO band edge associated with hydrogen in mixed PdD_xH_y. Whether this is the case or not can be determined in future experiments where the hydrogen content of the heavy water is better controlled. Additionally, our results motivate theoretical studies with mixed hydrogen and deuterium loading to verify under what conditions, if any, a splitting of the LO band near the band edge occurs.

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Appendix Table 1. 49 data points from 3 cells tested in 2007 and 2008 at 50-60°C.

No.	Experiment	Date	Freq. (THz)	XP(mW)
1	662n	3/25/2007	3.12	0
2	662n	3/25/2007	3.81	0
3	662n	3/25/2007	4.50	0
4	662n	3/25/2007	5.18	0
5	662n	3/25/2007	5.86	0
6	662n	3/25/2007	6.33	15
7	662n	3/25/2007	6.80	25
8	662i	3/21/2007	8.00	80
9	662g	3/20/2007	8.30	125
10	662k	3/22/2007	8.40	130
11	662i(2)	3/21/2007	8.48	80
12	662i(2)	3/21/2007	8.61	90
13	662i(2)	3/21/2007	9.06	60
14	662i(2)	3/21/2007	9.65	40
15	662i(2)	3/21/2007	10.95	30
16	662i(2)	3/21/2007	12.31	40
17	662i	3/21/2007	13.62	0
18	662i(2)	3/21/2007	13.68	20
19	662i	3/21/2007	14.23	70
20	662i(2)	3/21/2007	14.36	20
21	662f1	4/13/2007	14.50	140
22	662j1	4/15/2007	14.70	70
23	662w	3/31/2007	14.70	70
24	662y	4/2/2007	14.70	120
25	662a1	4/4/2007	14.70	80
26	662j1	4/15/2007	14.70	150
27	662s1	4/23/2007	14.70	66
28	669a1	5/8/2008	14.75`	350
29	662i(2)	3/21/2007	14.88	80
30	662f1	4/13/2007	15.20	160
31	662a1	4/4/2007	15.30	200
32	662f1	4/13/2007	15.82	140
33	662b2	5/5/2007	15.90	50
34	662w	3/31/2007	16.02	40
35	662f1	4/13/2007	16.45	80
36	662f1	4/13/2007	17.09	0
37	662i2	3/21/2007	18.23	0
38	662c2	5/5/2007	18.40	100
39	662w	3/31/2007	18.56	70
40	662t1	4/25/2007	18.80	50
41	662i2	3/21/2007	18.87	0
42	670a	6/6/2008	19.28	100
43	662o	3/25/2007	19.40	200
44	662i2	3/21/2007	19.50	30
45	669u	4/30/2008	20.00	250
46	662x1	4/29/2007	20.50	250
47	662o2	5/17/2007	20.70	300
48	662i2	3/21/2007	21.40	130
49	669a1	5/8/2008	22.11	0

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